

## Claims

1. A battery charging state arithmetic operation device, characterized by comprising:

battery voltage detection means for detecting a voltage of a battery;

battery current detection means for detecting a current of the battery;

first current-voltage characteristic storage means for approximately obtaining a current-voltage characteristic of the battery in a first state as a currently used state by using voltage values and current values detected by the battery voltage detection means and the battery current detection means at plural sampling points and for storing it as a first current-voltage characteristic;

second current-voltage characteristic storage means for previously storing a second current-voltage characteristic in a second state where amount of extractive energy is smaller than that in the first state;

specified current value storage means for storing a specified load current value of the battery;

battery voltage calculation means with specified load for calculating a first battery voltage when the battery current is at the specified load current value by using the first current-voltage characteristic stored in the first

current-voltage characteristic storage means and for calculating a second battery voltage when the battery current is at the specified load current value by using the second current-voltage characteristic; and

charging state arithmetic operation means for calculating a charging state of the battery in the first state by using the first and the second battery voltages calculated by the battery voltage calculation means with specified load.

2. A battery charging state arithmetic operation device according to claim 1, characterized in that the battery charging state calculated by the battery charging state arithmetic operation means is corrected according to a performance level of the battery detected by using performance level detection means from a voltage  $V_c$  in the first current-voltage characteristic storage means at the time of the specified load current stored in the specified load current storage means and a voltage  $V_o$  in the first current-voltage characteristic storage means when a load current is zero.

3. A battery charging state arithmetic operation device according to claim 2, characterized in that the battery charging state is a remaining capacity which the battery can discharge before the battery voltage is lowered from the first battery voltage to the second battery voltage.

4. A battery charging state arithmetic operation device according to claim 3, characterized in that a correction gain

consistent with a characteristic of the battery is obtained by performance level correction gain calculation means from the performance level of the battery detected by the performance level detection means, the remaining capacity calculated by the battery charging state arithmetic operation device is divided by a maximum battery capacity of the battery corrected by the correction gain, and the battery charging state is calculated.

5. A battery charging state arithmetic operation device according to claim 4, characterized in that a current integration value obtained by current integrating means initialized at a time of execution of the battery charging state arithmetic operation means is added to or subtracted from the remaining capacity recited in claim 4, and the battery charging state is calculated.

6. A battery charging state arithmetic operation device according to claim 5, characterized in that from the current obtained by the battery current detection means, the current integration value obtained by the current integrating means provided with means initialized at the time of execution of the battery charging state arithmetic operation means is made to pass through a limiter having the battery charging state as an upper limit and is made to pass through a limiter having a lower limit value obtained by subtracting the maximum battery capacity from the battery charging state.

7. A battery charging state arithmetic operation device comprising:

battery voltage detection means for detecting a voltage of a battery;

battery current detection means for detecting a current of the battery;

first current-voltage characteristic storage means for approximately obtaining a current-voltage characteristic of the battery in a first state as a currently used state by using voltage values and current values detected by the battery voltage detection means and the battery current detection means at plural sampling points and for storing it as a first current-voltage characteristic;

second current-voltage characteristic storage means for previously storing a third current-voltage characteristic in a third state where the amount of extractive energy is larger than that in the first state and a second current-voltage characteristic in a second state where the amount of extractive energy is smaller than that in the first state;

specified current value storage means for storing a specified load current value of the battery;

battery voltage calculation means with specified load for calculating a first battery voltage when the battery current is at the specified load current value by using the first current-voltage characteristic stored in the first

current-voltage characteristic storage means, for calculating a second battery voltage when the battery current is at the specified load current value by using the second current-voltage characteristic, and for calculating a third battery voltage when the battery current is at the specified load current value by using the third current-voltage characteristic; and

charging state arithmetic operation means for calculating a charging state of the battery in the first state by using the first, the second and the third battery voltages calculated by the battery voltage calculation means with specified load.

8. A battery charging state arithmetic operation device according to claim 7, characterized in that the third state is a completely charged state, and the second state is a deep discharge state.

9. A battery charging state arithmetic operation device according to claim 7, further comprising temperature detection means for detecting a temperature of the battery currently being used, characterized in that the second current-voltage characteristic storage means previously stores, as candidates of the second current-voltage characteristic, current-voltage characteristics at plural specified temperatures from a high temperature to a low temperature in an operating temperature range of battery, and stores, as candidates of the third

current-voltage characteristic, current-voltage characteristics at the plural specified temperatures, and selects, as the second current-voltage characteristic and the third current-voltage characteristic, characteristics corresponding to the battery temperature detected by the temperature detection means from the plural stored candidates of the second current-voltage characteristic and the plural candidates of the third current-voltage characteristic.

10. A battery charging state arithmetic operation device according to any one of claims 7 to 9, characterized in that the charging state arithmetic operation means calculates a ratio of a difference between the first battery voltage and the second battery voltage to a difference between the third battery voltage and the second battery voltage.

11. A battery charging state arithmetic operation device according to any one of claims 7 to 9, characterized in that the specified load current value of the battery is directly inputted to the battery voltage calculation means with specified load from an external device.

12. A battery charging state arithmetic operation method, characterized by comprising:

a step of detecting voltage values and current values of a battery in a first state as a currently used state at plural sampling points;

a step of approximately obtaining a current-voltage

characteristic of the battery in the first state by using the voltage values and the current values of the battery detected at the plural sampling points and storing it as a first current-voltage characteristic;

a step of previously storing the third current-voltage characteristic in a third state where the amount of extractive energy is larger than that in the first state and the second current-voltage characteristic in a second state where the amount of extractive energy is smaller than that in the first state;

a step of storing a specified load current value of the battery;

a step of calculating a first battery voltage when the battery current is at the specified load current value by using the first current-voltage characteristic, calculating a second battery voltage when the battery current is at the specified load current value by using the second current-voltage characteristic, and calculating a third battery voltage when the battery current is at the specified load current value by using the third current-voltage characteristic; and

a step of calculating a charging state of the battery in the first state by using the first, the second and the third battery voltages calculated.

13. A battery charging state arithmetic operation

method according to claim 12, characterized in that the third state is a completely charged state, and the second state is a deep discharge state.

14. A battery charging state arithmetic operation method according to claim 12 or 13, characterized in that at the step of calculating the battery charging state, a ratio of a difference between the first battery voltage and the second battery voltage to a difference between the third battery voltage and the second battery voltage is calculated.